In situ radioactivity measurements and recent applications in the aquatic environment

C. Tsabaris[1,*], D.L. Patiris[1], E.G. Androulakaki[1,2], G. Eleftheriou[1], F. K. Pappa[1,3], S. Alexakis[1]

[1]*Institute of Oceanography, Hellenic Centre for Marine Research (HCMR), Greece*

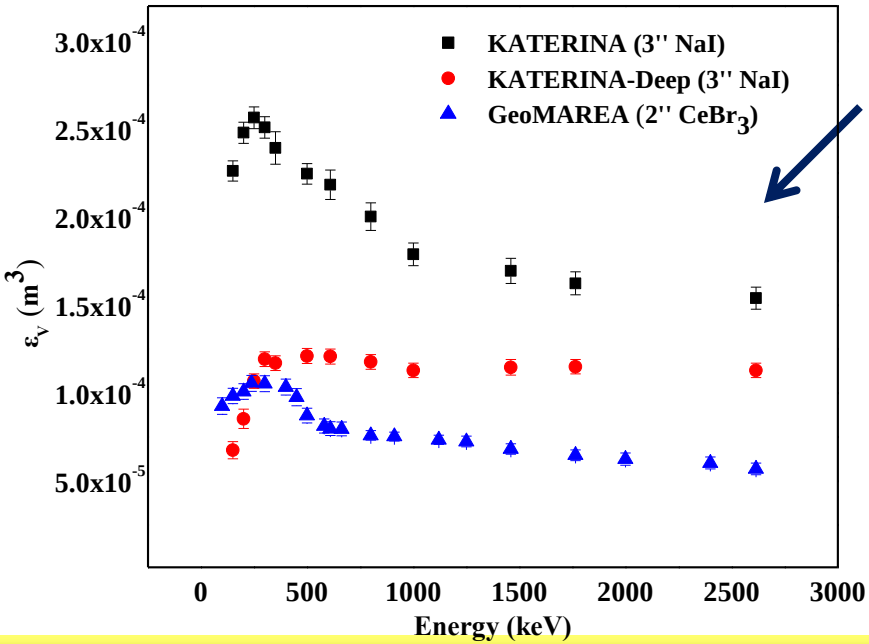
[2]*National Technical University of Athens (NTUA), Greece*

[3]*University of the Aegean, Department of Marine Sciences, Mytilene, Lesvos, Greece.*

**tsabaris@hcmr.gr*

C. Tsabaris, D.L. Patiris, E.G. Androulakaki, G. Eleftheriou, F. K. Pappa, S. Alexakis

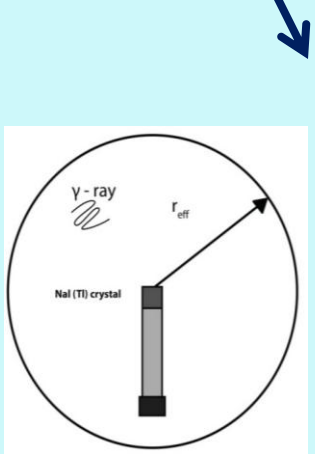
Detection efficiency (ε_V) calibration of the 3 underwater gamma-ray detection systems

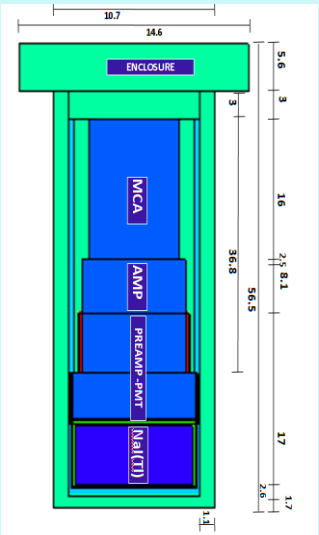


ARI 66 (2008); ARI 142 (2018); JER 204 (2019)

Experimentally evaluated Monte Carlo (MC) simulations: MCNP5/-X/-CP , FLUKA, Geant codes.

Detector models with different crystals (NaI(Tl), $CeBr_3$) and enclosures (stainless steel, acetal)





Quantification:

Window analysis (gross cps, ROI's)
Full-energy peak analysis (detection efficiency calibration)
Full spectrum analysis (FSA)

ARI 114 (2016)

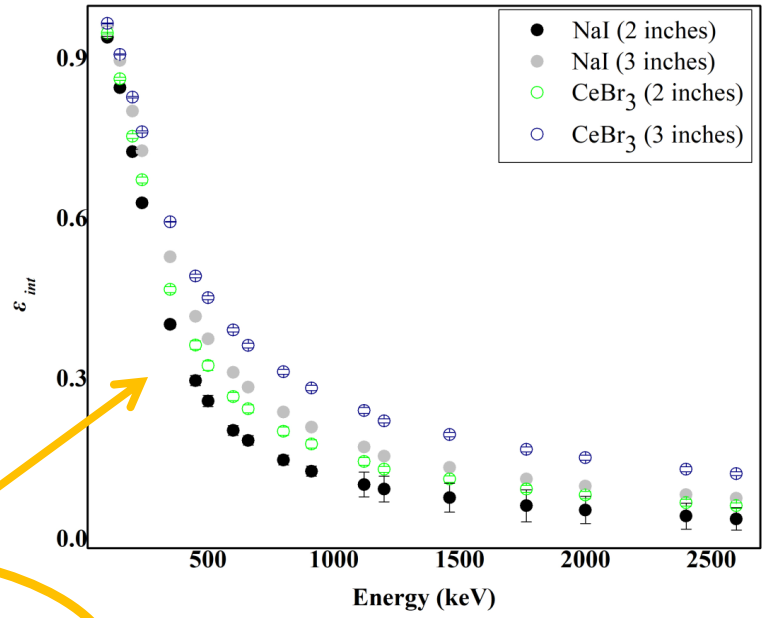
Efficiency transfer methodology:

MC detection efficiency (ε_V) results combined with partial MC simulation:

Reduced computing time (from days to minutes)

Test case: KATERINA system with 3" $CeBr_3$ crystal for measurements in the seawater

MC data obtained within min



$$\varepsilon_V\,|_{3''(CeBr_3)} = \varepsilon_V\,|_{3''(NaI)} \cdot \frac{\varepsilon_{int}\,|_{3''(CeBr_3)}}{\varepsilon_{int}\,|_{3''(NaI)}}$$

ε_{int} : $\frac{\text{events detected}}{\text{events emitted}}$ |*inside the crystal*

Results evaluation with analytical MC showed agreement within 5%

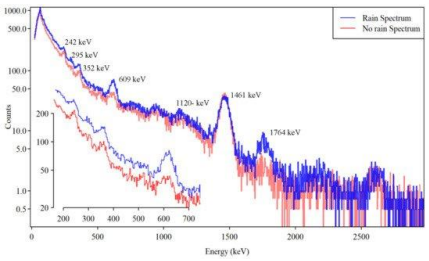
C. Tsabaris, D.L. Patiris, E.G. Androulakaki, G. Eleftheriou, F. K. Pappa, S. Alexakis

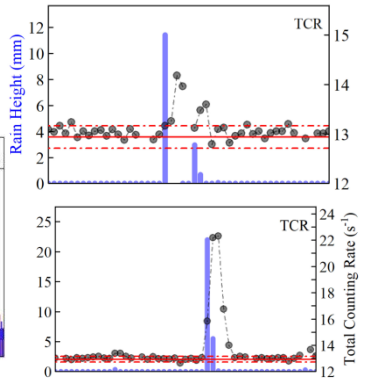
Stationary applications (KATERINA, GeoMAREA) :

Climate Studies: Rainfall investigation in marine areas Greece Italy

Ligurian Sea: Deployment 6 m below sea level
4 months continuous monitoring (07 - 10/ 2016)

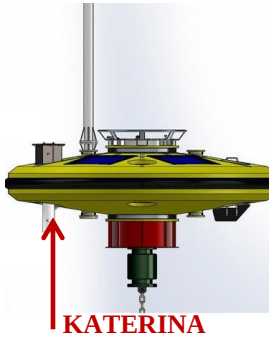
JMSE 9 (2021) 903

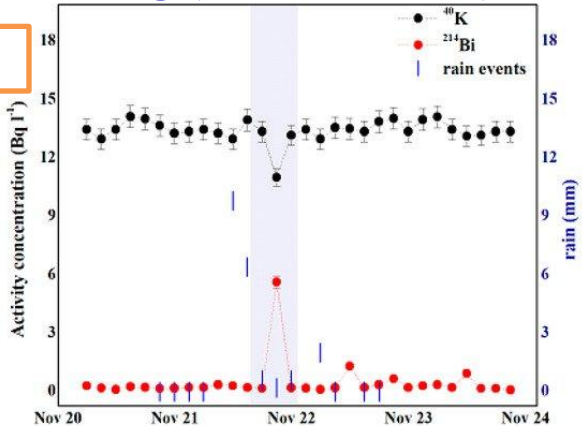




Athos: Deployment 1 m below sea level
3 months monitoring (11/ 19 - 02/ 20)

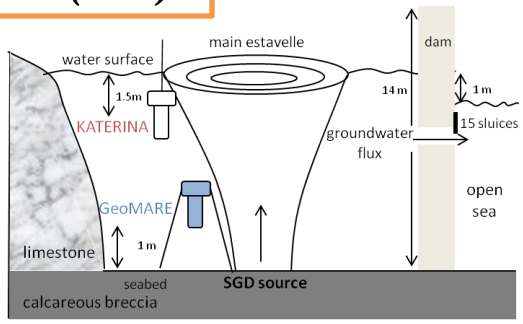
JMSE 9 (2021) 77

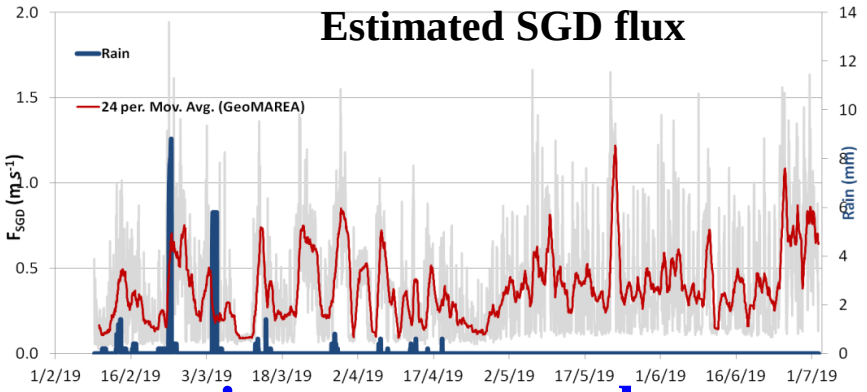




Water resources: Submarine Groundwater Discharge quantification

JER 216 (2020)



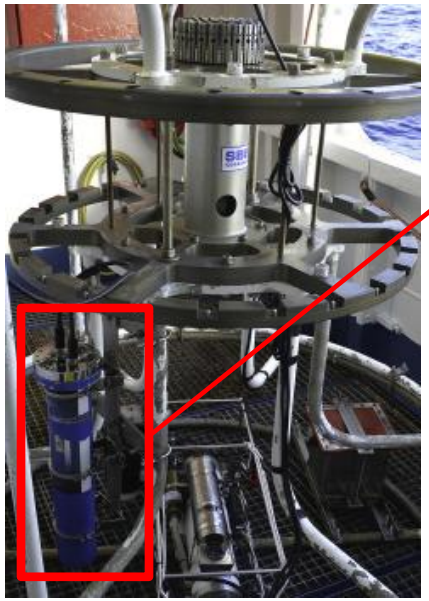


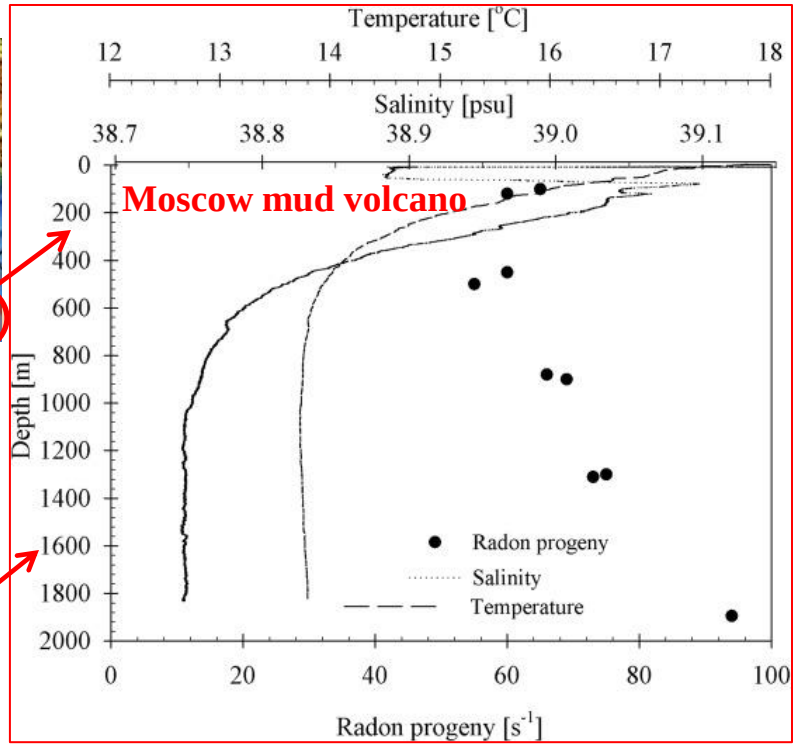
12 m^3 s^{-1} average discharge using a non-steady state flux-by-difference box model and time series data

Mobile applications (KATERINA-Deep):

Deep Sea research: Submarine Volcanic Arc - Olimpi field

Deep Sea Res 171 (2020)





- rosette velocity 60m/min
- one spectrum per min
- water depth 0-1900m
- **9 analyzed spectra**

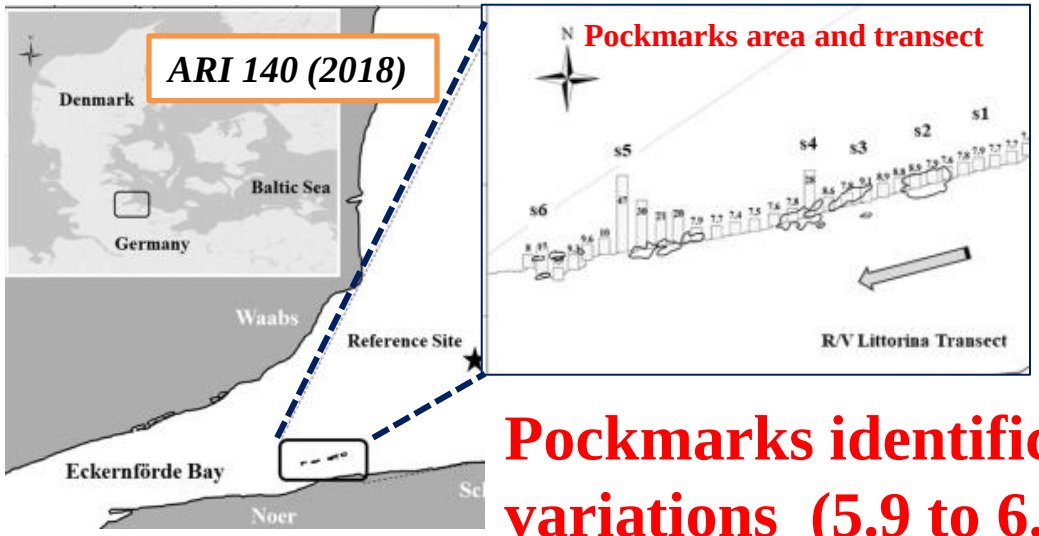
(average values in depth)

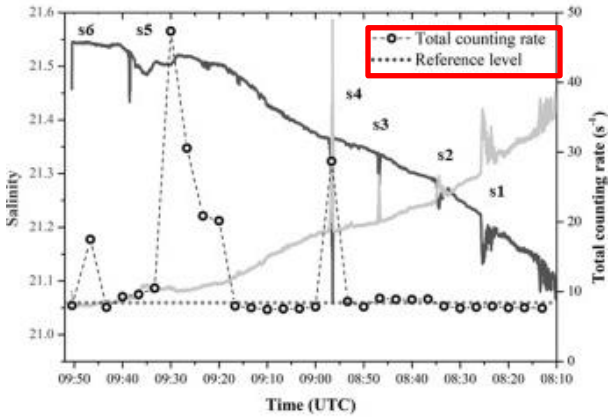
Higher ^{214}Bi counting rates near volcano structures indicates natural **gases fluxes**

Maximum activity concentration of **0.3 Bq l^{-1}**

Mobile applications (KATERINA) :

Geophysical research: Marine Pockmarks localization Germany

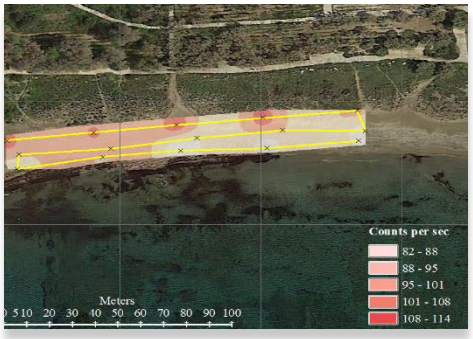




Pockmarks identification via salinity and ^{222}Rn variations (5.9 to 6.9 Bq l^{-1} in pockmarks region)

Radioecology: Radiological mapping of coastal areas Lavrio, Lesvos

- Lavrio: cps (82 – 114 (s^{-1}))



- Lesvos: ^{214}Bi (60-70 Bq/kg)

References:

[*ARI 66 (2008)*] C.Tsabaris *et al.*, Appl. Radiat. Isot. 66, 1419 (2008)
[*JER 204 (2019)*] C.Tsabaris *et al.*, J Environ. Radioact. 204, 12 (2019)
[*ARI 142 (2018)*] C.Tsabaris *et al.*, Appl. Radiat. Isot. 142, 120 (2018)
[*ARI 114 (2016)*] E.G. Androulakaki et al., Appl. Radiat. Isot. 114, 76 (2016)
[*JMSE 9 (2021)77*] C.Tsabaris *et al.*, J. Mar. Sci. Eng., 9(1), 77 (2021)
[*JMSE 9 (2021) 903*] D.L.Patiris *et al.*, J. Mar. Sci. Eng., 9(1), 903 (2021)
[*JER 216 (2020)*] G. Eleftheriou *et al.*, J Environ. Radioact. 216 (2020)
[*Deep Sea Res 171 (2020)*] C.Tsabaris *et al.*, *Deep Sea Res.* 142, 171 (2020)
[*ARI 140 (2018)*] C.Tsabaris *et al.*, Appl. Radiat. Isot. 140, 305 (2018)